

ExMC'S STRATEGY AND APPROACH FOR ACHIEVING PROGRESSIVELY EARTH INDEPENDENT MEDICAL OPERATIONS FOR NASA HUMAN SPACEFLIGHT EXPLORATION MISSIONS

Kris Lehnhardt, MD
Element Scientist, ExMC

Benjamin Easter, MD, MBA
Acting Element Scientist, ExMC

Shean Phelps, MD, MPH
Associate Scientist, ExMC

Nancy Fleming
Element Manager, ExMC

2022 NASA Human Research Program Investigators' Workshop

February 7, 2022

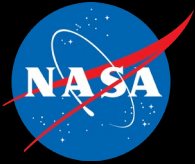
"Expanding the Boundaries of Space Medicine and Technology"

- **Risk Title:** Risk of Adverse Health Outcomes & Decrements in Performance due to Medical Conditions that occur In Mission
- **Risk Statement:** Given that medical conditions will occur during human spaceflight missions, there is a possibility of adverse health outcomes & decrements in performance during these missions and for long term health.
- **What is required for the Medical Risk to be acceptable:** High confidence that astronauts can accomplish mission medical tasks in a progressively autonomous fashion

DRM Categories	Mission Type and Duration	Operations		Long-Term Health	
		LxC	Risk Disposition *	LxC	Risk Disposition *
Low Earth Orbit	Short (<30 days)	3x2	Accepted	3x2	Accepted
	Long (30 days-1 year)	4x2	Accepted	4x2	Accepted
Lunar Orbital	Short (<30 days)	4x2	Accepted	3x2	Accepted
	Long (30 days-1 year)	5x3	Requires Mitigation	4x2	Requires Characterization
Lunar Orbital + Surface	Short (<30 days)	4x3	Requires Characterization	4x2	Requires Characterization
	Long (30 days-1 year)	5x4	Requires Mitigation	4x4	Requires Characterization
Mars	Preparatory (<1 year)	5x4	Requires Mitigation	4x4	Requires Characterization
	Mars Planetary (730-1224 days)	5x5	Requires Mitigation	5x4	Requires Characterization

DRM = design reference mission

L x C = likelihood and consequence



MEDICAL RISK INCREASES WITH DISTANCE FROM EARTH



International Space Station

Gateway

Lunar Surface

Mars Transit

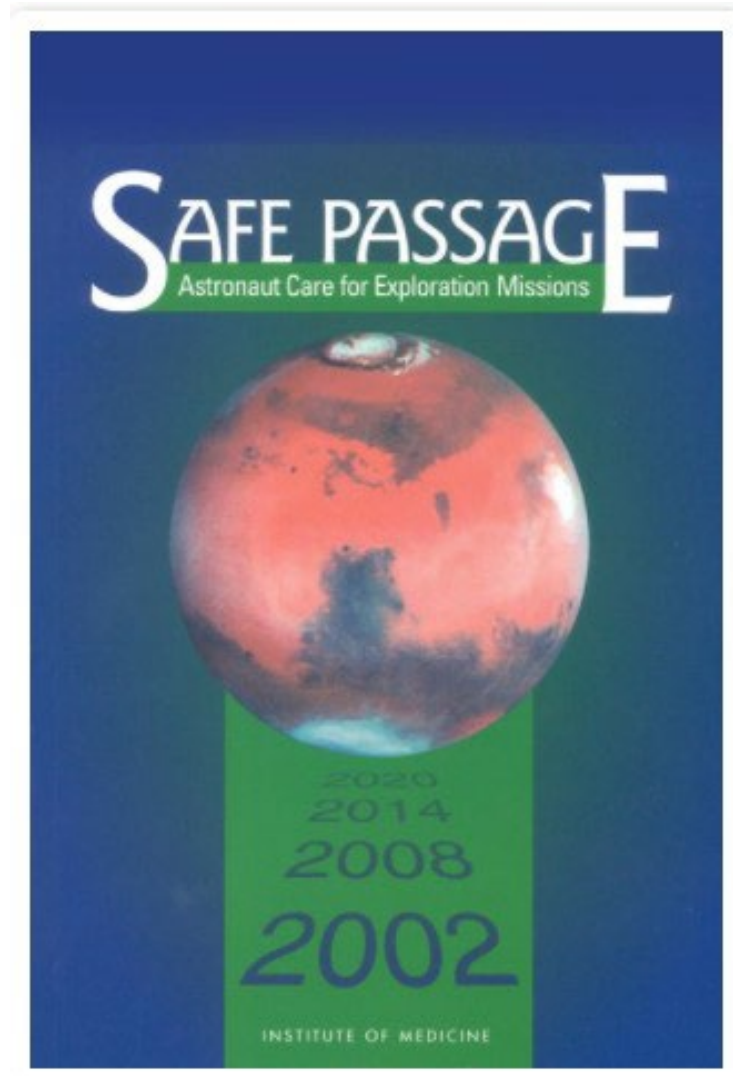
CURRENT STATE

- 180-day to 360-day mission duration
- Strong consumables resupply
- Real-time communications
- Regular sample returns to Earth
- Emergency evacuations possible
- Relatively large internal volume
- Limited onboard medical care (Earth-reliant)

EXPLORATION CLASS MISSION

- 650-day to > 900-day mission duration
- Zero consumables resupply
- No real-time communications + blackouts
- No sample returns to Earth
- No evacuations possible
- (Likely) much smaller internal volume
- Expanded onboard medical care (crew/vehicle-reliant)

Why does the Medical Risk matter for exploration missions?



Human Exploration of Mars: Preliminary Lists of Crew Tasks



Autonomous Medical Care for Exploration Class Space Missions

Hamilton, Douglas MD, PhD; Smart, Kieran MD, MPH; Melton, Shannon BS; Polk, James D. DO; Johnson-Throop, Kathy PhD

[Author Information](#) ☺

Journal of
Trauma and
Acute Care Surgery

The Journal of Trauma: Injury, Infection, and Critical Care: April 2008 - Volume 64 - Issue 4 - p S354-S363

doi: 10.1097/TA.0b013e31816c005d



Earth-Independent Medical Operations (EIMO)



Medical Training

NASA/TM-2014-217384



Identification of Medical Training Methods for Exploration Missions

Rebecca S. Blue, MD, MPH
Laura M. Bridge, MD
Natacha G. Chough, MD
James Cushman, MD, MPH
Muska Khpal, MBBS
Sharmi Watkins, MD, MPH

In-situ Medication Analysis



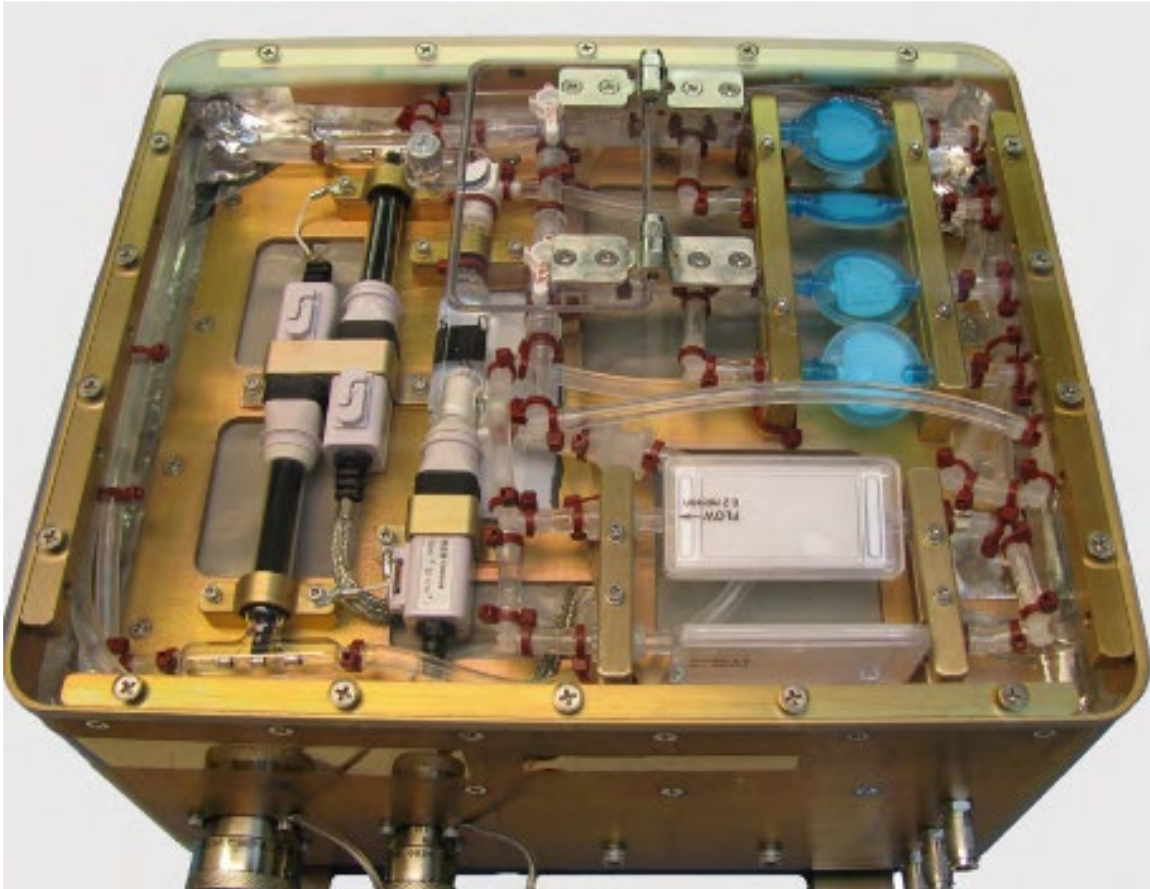
Procedural Guidance



In-situ Diagnostics



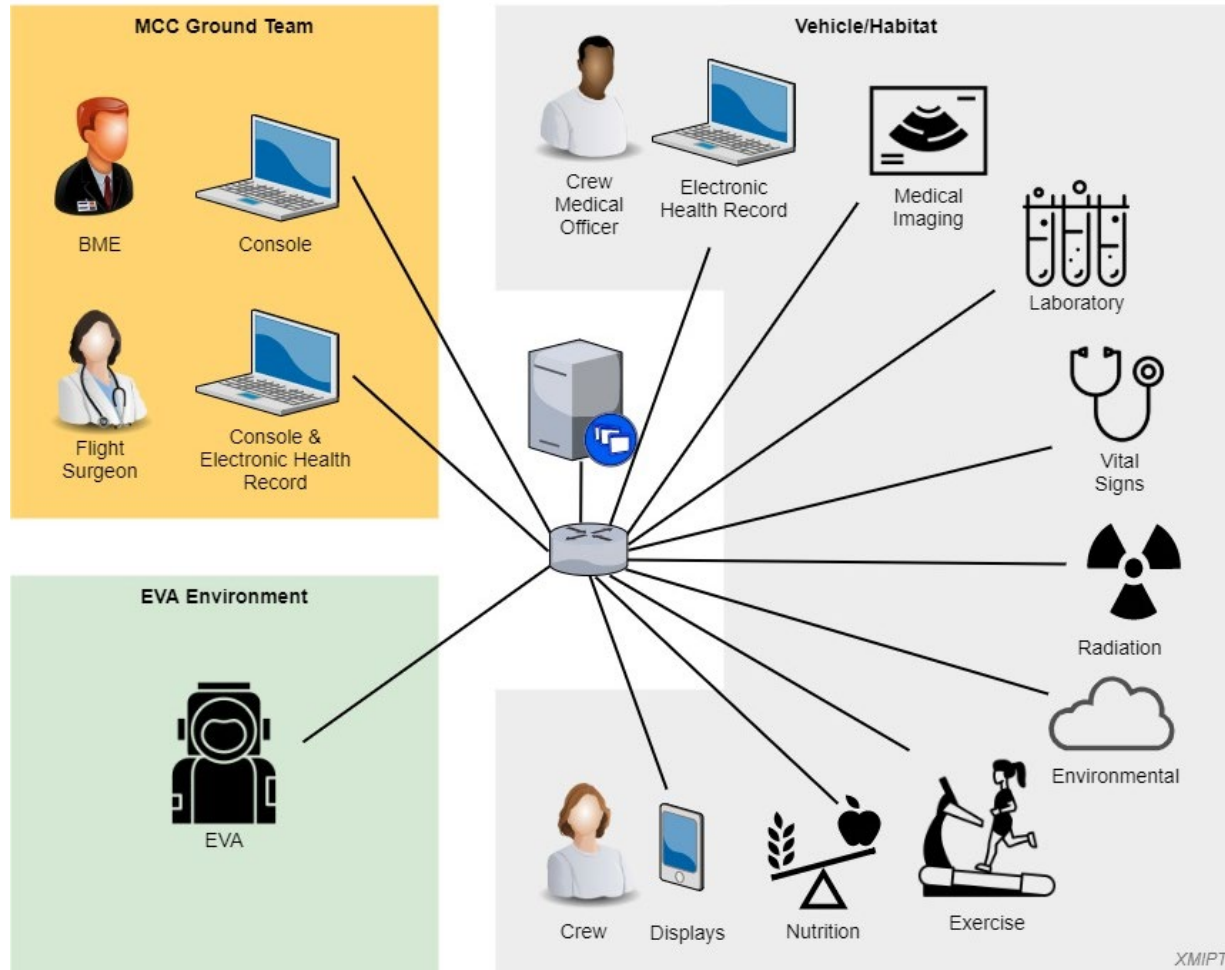
In-situ IV Fluid Generation



Inventory Management/Consumables Tracking



Integrated Data Architecture



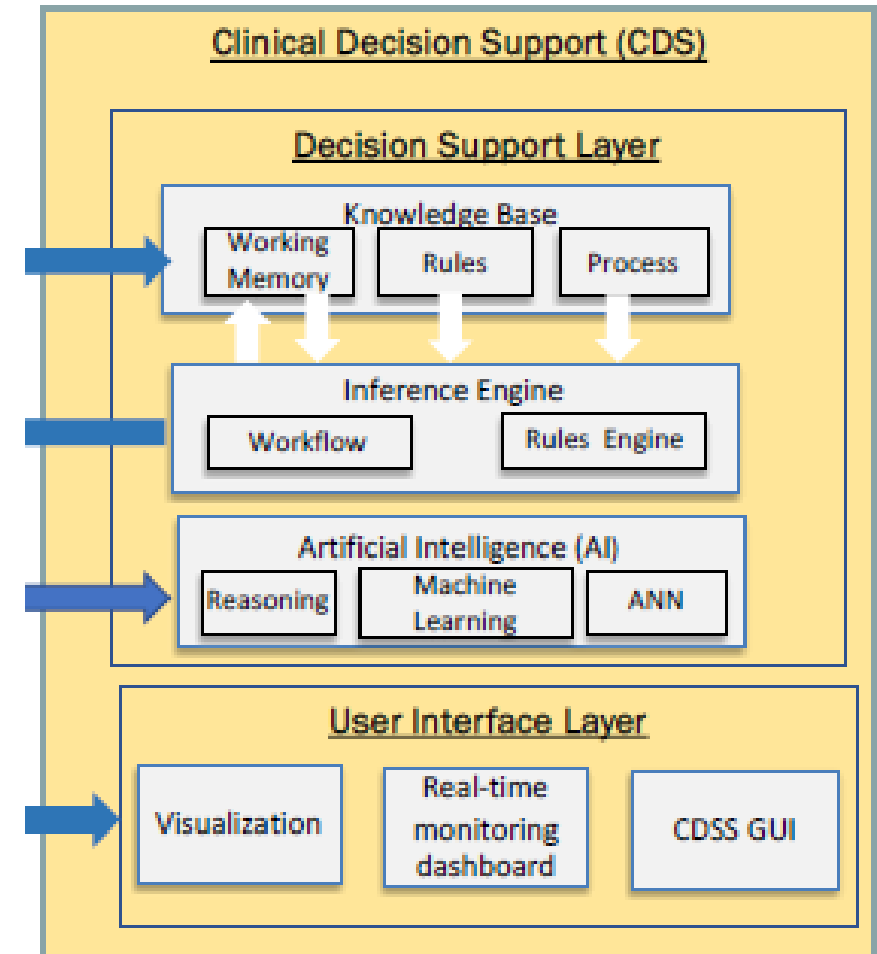
Multifunctional Medical Devices



Expanded In-situ Diagnostics



Clinical Decision Support

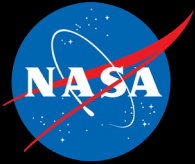


What's Next?

“Expanding the Boundaries of Space Medicine and Technology”

- **Identify stakeholders and ascertain high-level EIMO needs, goals, and objectives**
- **Solicit input from broader human spaceflight community**
- **Develop an EIMO Concept of Operations – outlines the vision for autonomous exploration medical care**
- **Share EIMO vision internally and externally to NASA**

- **Build tactical plan based on iteration and demonstration to progressively increase astronaut self-reliance for medical care**
- **Maximize utility of ground testbeds and analog environments (including ISS)**
- **Targets: Mars Transit Habitat, Artemis Base Camp**
- **Ultimate goal = astronauts taking care of astronauts, far from home, when they are healthy and when they are sick or injured, with Earth support as needed**



QUESTIONS?



Credit: Phil Smith

Email: kris.lehnhardt@nasa.gov